

PATENT COOPERATION TREATY

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INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY


(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

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Applicant's or agent's file reference F18509 GSK	FOR FURTHER ACTION		See Form PCT/PEA/416
International application No. PCT/IB2004/003758	International filing date (day/month/year) 17.11.2004	Priority date (day/month/year) 18.11.2003	
International Patent Classification (IPC) or national classification and IPC C07C29/141, C07C45/50, C07C47/02, C07C31/125			
Applicant SASOL TECHNOLOGY(PROPRIETARY) LIMITED			
<p>1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 6 sheets, including this cover sheet.</p> <p>3. This report is also accompanied by ANNEXES, comprising:</p> <p>a. <input checked="" type="checkbox"/> sent to the applicant and to the International Bureau a total of 12 sheets, as follows:</p> <p><input checked="" type="checkbox"/> sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).</p> <p><input type="checkbox"/> sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.</p> <p>b. <input type="checkbox"/> (sent to the International Bureau only) a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).</p>			
<p>4. This report contains indications relating to the following items:</p> <p><input checked="" type="checkbox"/> Box No. I Basis of the opinion</p> <p><input type="checkbox"/> Box No. II Priority</p> <p><input type="checkbox"/> Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability</p> <p><input type="checkbox"/> Box No. IV Lack of unity of invention</p> <p><input checked="" type="checkbox"/> Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement</p> <p><input type="checkbox"/> Box No. VI Certain documents cited</p> <p><input checked="" type="checkbox"/> Box No. VII Certain defects in the international application</p> <p><input type="checkbox"/> Box No. VIII Certain observations on the international application</p>			
Date of submission of the demand 14.09.2005		Date of completion of this report 07.02.2006	
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465		Authorized Officer Österle, C Telephone No. +49 89 2399-8120	



**INTERNATIONAL PRELIMINARY REPORT
ON PATENTABILITY**

International application No.
PCT/IB2004/003758

Box No. I Basis of the report

1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.
- ☐ This report is based on translations from the original language into the following language , which is the language of a translation furnished for the purposes of:
- ☐ international search (under Rules 12.3 and 23.1(b))
 - ☐ publication of the international application (under Rule 12.4)
 - ☐ international preliminary examination (under Rules 55.2 and/or 55.3)
2. With regard to the **elements*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

Description, Pages

1-20 as originally filed

Claims, Numbers

1-23 received on 16.09.2005 with letter of 14.09.2005

- ☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing
3. ☐ The amendments have resulted in the cancellation of:
- ☐ the description, pages
 - ☐ the claims, Nos.
 - ☐ the drawings, sheets/figs
 - ☐ the sequence listing (*specify*):
 - ☐ any table(s) related to sequence listing (*specify*):
4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
- ☐ the description, pages
 - ☐ the claims, Nos.
 - ☐ the drawings, sheets/figs
 - ☐ the sequence listing (*specify*):
 - ☐ any table(s) related to sequence listing (*specify*):

* If item 4 applies, some or all of these sheets may be marked "superseded."

**INTERNATIONAL PRELIMINARY REPORT
ON PATENTABILITY**

International application No.
PCT/IB2004/003758

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims	1-23
	No: Claims	
Inventive step (IS)	Yes: Claims	1-23
	No: Claims	
Industrial applicability (IA)	Yes: Claims	1-23
	No: Claims	

2. Citations and explanations (Rule 70.7):

see separate sheet

Box No. VII Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

Re Item V

**Reasoned statement with regard to novelty, inventive step or industrial applicability;
citations and explanations supporting such statement**

- D1: EP-A-0 602 442 (HOECHST AKTIENGESELLSCHAFT) 22 June 1994 (1994-06-22)
- D2: US-B1-6 307 093 (GODWIN ALLEN DAVID ET AL) 23 October 2001 (2001-10-23)
- D3: US-A-5 886 237 (PACKETT ET AL) 23 March 1999 (1999-03-23)
- D4: EP-A-0 529 698 (SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ B.V) 3 March 1993 (1993-03-03)
- D5: KRANENBURG M ET AL: "NEW DIPHOSPHINE LIGANDS BASED ON HETEROCYCLIC AROMATICS INDUCING VERY HIGH REGIOSELECTIVITY IN RHODIUM-CATALYZED HYDROFORMYLATION: EFFECT OF THE BITE ANGLE" ORGANOMETALLICS, WASHINGTON, DC, US, vol. 14, no. 6, 1 June 1995 (1995-06-01), pages 3081-3089, XP000565303 ISSN: 0276-7333
- D6: CASEY C P ET AL: "DIPHOSPHINES WITH NATURAL BITE ANGLES NEAR 120 DEG INCREASE SELECTIVITY FOR N-ALDEHYDE FORMATION IN RHODIUM-CATALYZED HYDROFORMYLATION" JOURNAL OF THE AMERICAN CHEMICAL SOCIETY, AMERICAN CHEMICAL SOCIETY, WASHINGTON, DC, US, vol. 114, no. 14, 1 July 1992 (1992-07-01), pages 5535-5543, XP000576101 ISSN: 0002-7863

1. Novelty (Article 33(2) PCT):

- 1.1 D1, considered the closest prior art discloses the hydroformylation of olefins originating from a Fischer-Tropsch synthesis. In D1 the olefin feedstock reacts with CO and H₂ in the presence of a catalyst system comprising rhodium and a water-soluble salt consisting of a phosphine anion and a tetraorganophosphine cation.

D2 discloses the hydroformylation of olefins using a catalyst system comprising rhodium and a triorganophosphorous ligand. D2 mentions the use of a mixture of monodentate and bidentate phosphorous ligands as a possibility. Feedstock can

originate from a variety of processes of which the Fisher-Tropsch process is mentioned as one of many (see column 2, last paragraph).

D3 and D4 disclose the use of rhodium catalysts comprising bidentate phosphine ligands in the hydroformylation of olefins.

D5 and D6 disclose the use of rhodium catalysts comprising bidentate phosphine as well as monodentate ligands in the hydroformylation of olefins. The olefins used are pure, feedstock originating from a Fischer-Tropsch process is not disclosed.

- 1.2 Claim 1 differs from D1-D4 in that a combination of a monodentate and a bidentate phosphorous ligand is used in the hydroformylation reaction.

Claim 1 differs from D5 and D6 in that the feedstock used originates from a Fischer-Tropsch process.

- 1.3 Present claim 1 as well as dependent claims 2-25 then can be considered novel.

2. Inventive Step (Article 33(3) PCT):

- 2.1 The technical effect linked to the difference between the subject-matter of claim 1 and D1-D6 is that Fischer-Tropsch derived feedstock comprising impurities can be used in the hydroformylation reaction without deactivation of the catalyst system.
- 2.2 The technical problem then can be seen in providing an improved catalyst system which does not suffer from deactivation/loss of activity when used with feedstock derived from a Fischer-Tropsch process.
- 2.3 The solution suggested is to use a catalyst system comprising $\text{Rh}(\text{acac})(\text{CO})_2$, $\text{Rh}(\text{acac})(\text{CO})(\text{TPP})$, $[\text{Rh}(\text{OAc})_2]_2$, Rh_2O_3 , $\text{Rh}_4(\text{CO})_{12}$, $\text{Rh}_6(\text{CO})_{16}$, $\text{Rh}(\text{CO})_2(\text{dipivaloyl methanoate})$, or $\text{Rh}(\text{NO}_3)_2$.

From the description is evident that rhodium catalysts comprising a variety of combinations of monodentate and bidentate ligands solve the technical problem.

**INTERNATIONAL PRELIMINARY
REPORT ON PATENTABILITY
(SEPARATE SHEET)**

International application No.

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The subject-matter of claim 1 as well as of claims 2-23 thus can be considered inventive.

3. Industrial Applicability (Article 33(4) PCT):

The subject-matter of claims 1-25 is considered industrially applicable.

Re Item VII

Certain defects in the international application

Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in the documents D1 and D5/D6 is not mentioned in the description, nor are these documents identified therein.

CLAIMS

1. A process for producing oxygenated products from a Fischer-
5 Tropsch derived olefinic feedstock, which process includes reacting the feedstock, in a hydroformylation reaction stage, with carbon monoxide and hydrogen at an elevated reaction temperature and at a superatmospheric reaction pressure in the presence of a hydroformylation catalyst system, which comprises a mixture, combination or complex of

10 (i)

$\text{Rh}(\text{acac})(\text{CO})_2$ where 'acac' is acetylacetonate, $\text{Rh}(\text{acac})(\text{CO})(\text{TPP})$ where 'acac' is acetylacetonate and 'TPP' is triphenylphosphine, $[\text{Rh}(\text{OAc})_2]_2$ where 'OAc' is acetate, Rh_2O_3 , $\text{Rh}_4(\text{CO})_{12}$, $\text{Rh}_6(\text{CO})_{16}$, $\text{Rh}(\text{CO})_2(\text{dipivaloyl methanoate})$, or $\text{Rh}(\text{NO}_3)_2$;

15 (ii) carbon monoxide, CO;

(iii) hydrogen, H_2 ;

(iv) as a primary ligand, a monodentate phosphorus ligand; and

20 (v) as a secondary ligand, a bidentate phosphorus ligand which confers resistance on the catalyst system to poisoning arising from the presence of undesired components in the Fischer-Tropsch derived feedstock.

2. A process according to Claim 1, wherein the hydroformylation
25 reaction stage comprises a hydroformylation reactor, with the process including initially preparing the catalyst system by dissolving component (i), together with the ligands, in a solvent, to produce a catalyst solution, and heating the catalyst solution in the reactor in the presence of synthesis gas comprising CO and H_2 to form an active hydroformylation catalyst system in which the rhodium
30 concentration in the catalyst solution in the hydroformylation reactor is from 10 to 1000 ppm.

3. A process according to Claim 1 or Claim 2, wherein the monodentate phosphorus ligand is used in a molar excess, relative to the rhodium, of from 50:1 to 1000:1.

5 4. A process according to any one of Claims 1 to 3 inclusive, wherein the bidentate phosphorus ligand is employed at a lower ligand to rhodium molar ratio than the monodentate phosphorus ligand, and wherein the bidentate phosphorus ligand to rhodium ratio is from 0.2:1 to 100:1.

10 5. A process according to any one of Claims 1 to 4 inclusive, wherein the monodentate phosphorus ligand is



where all R^a are the same or are dissimilar, and are each a branched or straight chain alkyl or aryl radical.

15

6. A process according to Claim 5 wherein, in the ligand of formula (L1a), each R^a is an aryl group and all R^a are the same.

20 7. A process according to Claim 6 wherein, in the ligand of formula (L1a), each R^a is phenyl so that ligand (L1a) is triphenylphosphine.

8. A process according to any one of Claims 1 to 4 inclusive, wherein the monodentate phosphorus ligand is



25 where all R^a are the same or are dissimilar, and are each a branched or straight chain alkyl or aryl radical.

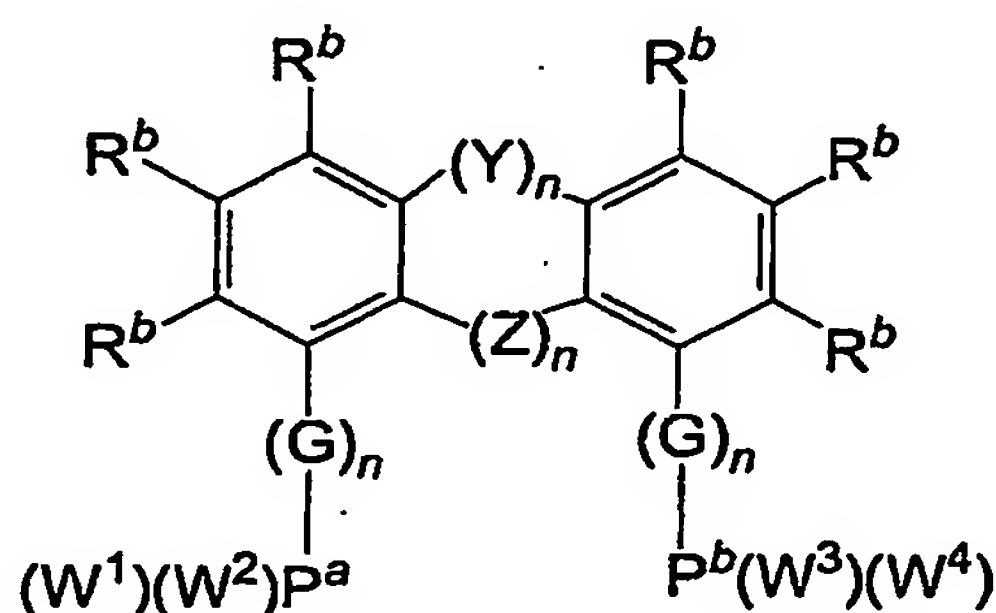
9. A process according to Claim 8 wherein, in the ligand of formula (L1b), each R^a is an aryl group and all R^a are the same.

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10. A process according to Claim 9 wherein, in the ligand of formula (L1b), each R^a is a substituted phenyl ring.

11. A process according to Claim 10, wherein the ligand (L1b) is tris(2,4-ditertiary butylphenyl) phosphite or tris(2-tertiary butylphenyl) phosphite.

12. A process according to any one of Claims 1 to 11 inclusive, wherein the bidentate phosphorus ligand is



(L2a)

20 wherein

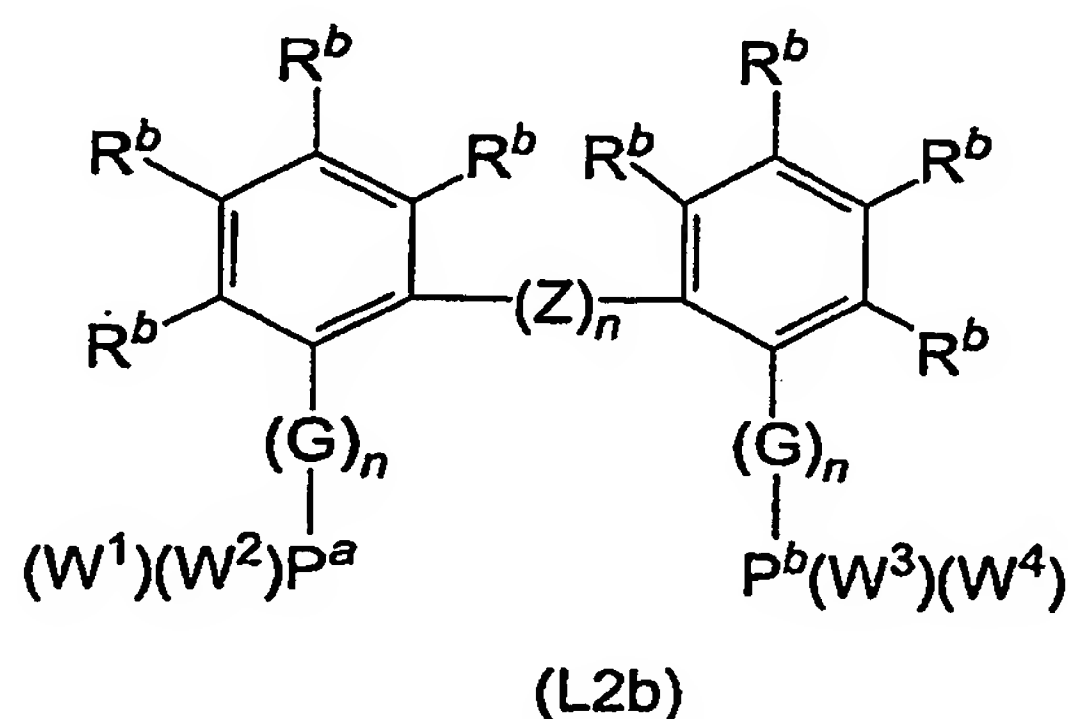
(i) all R^b are the same or are dissimilar, and are each H, alkyl, alkoxy, cycloalkyl, cycloalkoxy, heterocycloalkyl, aryl, heteroaryl, aryloxy, polyether, cyano, nitro, halogen, trifluoromethyl, $-C(O)R^c$, $-(R^d)C(O)R^c$, $-CHO$, $(R^d)CHO$, $-COOR^c$, $-(R^d)COOR^c$, $-COO^-M^+$, $-(R^d)COO^-M^+$, $-SO_3R^c$, $-(R^d)SO_3R^c$, $-SO_3^-M^+$, $-(R^d)SO_3^-M^+$, $-SR^c$, $-(R^d)SR^c$, $-SOR^c$, $-R^d(SOR^c)$, $-NR^c$, $-(R^d)NR^c$, $-N^+(R^c)(R^c)(X^-)$ or $-(R^d)N^+(R^c)(R^c)(X^-)$, wherein

(a) R^c and R^d are the same or different, and are each H, or a branched or straight chain alkyl, alkoxy, cycloalkyl, polyether, cycloalkoxy, heterocycloalkyl, aryl, heteroaryl or aryloxy radical;

(b) M^+ is a cation; and

- (c) X^- is an anion;
- (ii) Y and Z are independent bridges, are the same or different, and are each selected from the radicals $-O-$, $-N(R^c)-$, $-N^+(R^c)(R^c)(X^-)-$, $-N(C(O)R^c)-$, $-C(R^c)(R^c)-$, $-C(C(R^c)(R^c))-$, $-C(O)-$, $-S-$, $-Si(R^c)(R^c)-$, $-Si(OR^c)(OR^c)-$, $-P(R^c)-$ or $-P(OR^c)-$, where R^c and X^- are as hereinbefore defined;
- (iii) n (in $(Y)_n$ and $(Z)_n$) is, in each case, 0 or 1, with the proviso that n cannot be 0 for both Y and Z;
- (iv) W^1 , W^2 , W^3 and W^4 are the same or different, and are each an alkyl (branched or straight chain), alkoxy, cycloalkyl, cycloalkoxy, heterocycloalkyl, aryl, heteroaryl, aryloxy or trifluoromethyl radical;
- (v) a, b, in P^a and P^b , are used merely to identify the P atoms;
- (vi) each G is an independent linker radical, are the same or different, and is selected from $-O-$, $-N(R^f)-$, $-N^+(R^f)(R^f)(X^-)-$, $-C(R^f)(R^f)-$, $-S-$, $-Si(R^f)(R^f)-$, $-C(F_2)-$ or $-C(R^f)(F)-$, wherein
- (a) R^f is H, or a branched or straight chain alkyl, alkoxy, cycloalkyl, polyether, cycloalkoxy, heterocycloalkyl, aryl, heteroaryl or aryloxy radical, and with the proviso that when the radical contains more than one R^f , all R^f are the same or different;
- (b) X^- is as defined above; and
- (vii) n (in each $(G)_n$) is 0 or 1.

13. A process according to any one of Claims 1 to 11 inclusive, wherein the bidentate phosphorus ligand is



wherein

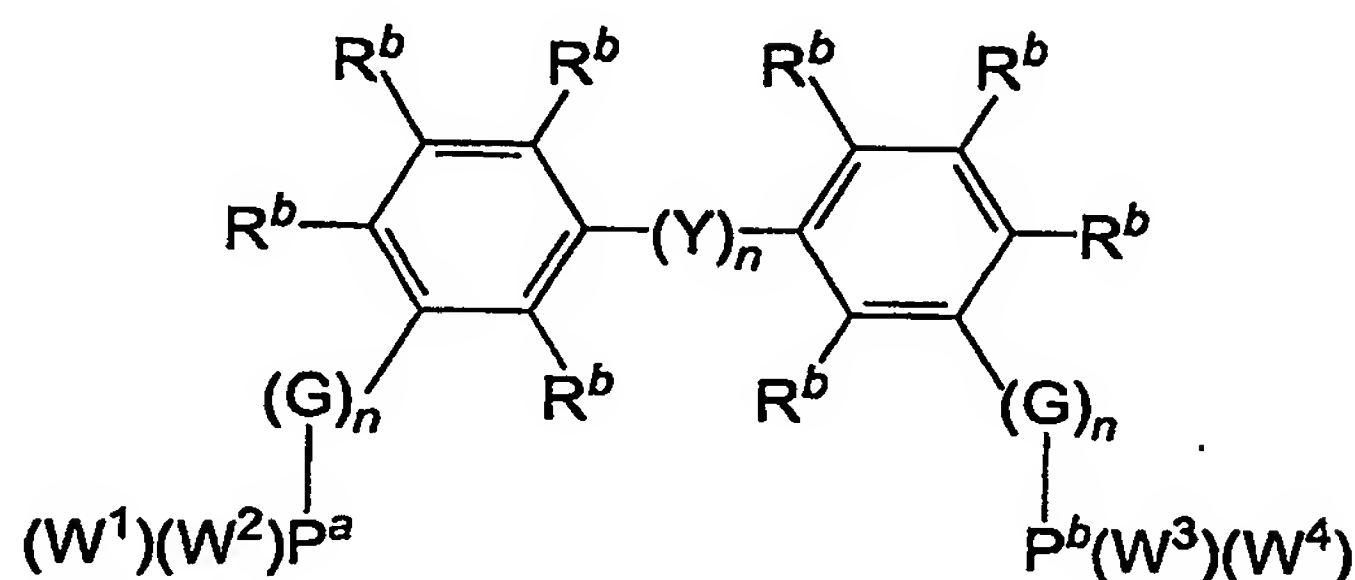
- 5 (i) all R^b are the same or are dissimilar, and are each H, alkyl, alkoxy, cycloalkyl, cycloalkoxy, heterocycloalkyl, aryl, heteroaryl, aryloxy, polyether, cyano, nitro, halogen, trifluoromethyl, $-C(O)R^c$, $-(R^d)C(O)R^c$, $-CHO$, $(R^d)CHO$, $-COOR^c$, $-(R^d)COOR^c$, $-COO^-M^+$, $-(R^d)COO^-M^+$, $-SO_3R^c$, $-(R^d)SO_3R^c$, $-SO_3^-M^+$, $-(R^d)SO_3^-M^+$, $-SR^c$, $-(R^d)SR^c$, $-SOR^c$, $-R^d(SOR^c)$, $-NR^c$, $-(R^d)NR^c$, $-N^+(R^c)(R^c)(X^-)$ or $-(R^d)N^+(R^c)(R^c)(X^-)$, wherein
- 10 (a) R^c and R^d are the same or different, and are each H, or a branched or straight chain alkyl, alkoxy, cycloalkyl, polyether, cycloalkoxy, heterocycloalkyl, aryl, heteroaryl or aryloxy radical;
- (b) M^+ is a cation; and
- (c) X^- is an anion;
- 15 (ii) Z is an independent bridge, and is selected from the radicals $-O-$, $-N(R^c)-$, $-N^+(R^c)(R^c)(X^-)-$, $-N(C(O)R^c)-$, $-C(R^c)(R^c)-$, $-C(C(R^c)(R^c))-$, $-C(O)-$, $-S-$, $-Si(R^c)(R^c)-$, $-Si(OR^c)(OR^c)-$, $-P(R^c)-$ or $-P(OR^c)-$, where R^c and X^- are as defined above;
- (iii) n (in $(Z)_n$) is 1;
- 20 (iv) W^1 , W^2 , W^3 and W^4 are the same or different, and are each an alkyl (branched or straight chain), alkoxy, cycloalkyl, cycloalkoxy, heterocycloalkyl, aryl, heteroaryl, aryloxy or trifluoromethyl radical;
- (v) a, b, in P^a and P^b , are used merely to identify the P atoms;
- (vi) each G is an independent linker radical, are the same or different, and is
- 25 selected from $-O-$, $-N(R^f)-$, $-N^+(R^f)(R^f)(X^-)-$, $-C(R^f)(R^f)-$, $-S-$, $-Si(R^f)(R^f)-$, $-C(F_2)-$ or $-C(R^f)(F)-$, wherein
- (c) R^f is H, or a branched or straight chain alkyl, alkoxy, cycloalkyl, polyether, cycloalkoxy, heterocycloalkyl, aryl, heteroaryl or aryloxy radical, and with the proviso that when the radical contains more
- 30 than one R^f , all R^f are the same or different;
- (d) X^- is as defined above; and

(vii) n (in each $(G)_n$) is 0 or 1.

14. A process according to any one of Claims 1 to 11 inclusive, wherein the bidentate phosphorus ligand is

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(L2c)

15 wherein

(i) all R^b are the same or are dissimilar, and are each H, alkyl, alkoxy, cycloalkyl, cycloalkoxy, heterocycloalkyl, aryl, heteroaryl, aryloxy, polyether, cyano, nitro, halogen, trifluoromethyl, $-C(O)R^c$, $-(R^d)C(O)R^c$, $-CHO$, $(R^d)CHO$, $-COOR^c$, $-(R^d)COOR^c$, $-COO^-M^+$, $-(R^d)COO^-M^+$, $-SO_3R^c$, $-(R^d)SO_3R^c$, $-SO_3^-M^+$, $-(R^d)SO_3^-M^+$, $-SR^c$, $-(R^d)SR^c$, $-SOR^c$, $-R^d(SOR^c)$, $-NR^c$, $-(R^d)NR^c$, $-N^+(R^c)(R^c)(X^-)$ or $-(R^d)N^+(R^c)(R^c)(X^-)$, wherein

20

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(a) R^c and R^d are the same or different, and are each H, or a branched or straight chain alkyl, alkoxy, cycloalkyl, polyether, cycloalkoxy, heterocycloalkyl, aryl, heteroaryl or aryloxy radical;

(b) M^+ is a cation; and

(c) X^- is an anion;

30

(ii) Y is an independent bridge, and is selected from the radicals $-O-$, $-N(R^c)-$, $-N^+(R^c)(R^c)(X^-)-$, $-N(C(O)R^c)-$, $-C(R^c)(R^c)-$, $-C(C(R^c)(R^c))-$, $-C(O)-$, $-S-$, $-Si(R^c)(R^c)-$, $-Si(OR^c)(OR^c)-$, $-P(R^c)-$ or $-P(OR^c)-$, where R^c and X^- are as hereinbefore defined;

- (iii) n (in $(Y)_n$) is 1;
- (iv) W^1 , W^2 , W^3 and W^4 are the same or different, and are each an alkyl (branched or straight chain), alkoxy, cycloalkyl, cycloalkoxy, heterocycloalkyl, aryl, heteroaryl, aryloxy or trifluoromethyl radical;
- 5 (v) a , b , in P^a and P^b , are used merely to identify the P atoms;
- (vi) each G is an independent linker radical, are the same or different, and is selected from $-O-$, $-N(R^f)-$, $-N^+(R^f)(R^f)(X^-)-$, $-C(R^f)(R^f)-$, $-S-$, $-Si(R^f)(R^f)-$, $-C(F_2)-$ or $-C(R^f)(F)-$, wherein
 - (e) R^f is H, or a branched or straight chain alkyl, alkoxy, cycloalkyl,
 10 polyether, cycloalkoxy, heterocycloalkyl, aryl, heteroaryl or aryloxy radical, and with the proviso that when the radical contains more than one R^f , all R^f are the same or different;
 - (f) X^- is as defined above; and
- (vii) n (in each $(G)_n$) is 0 or 1.

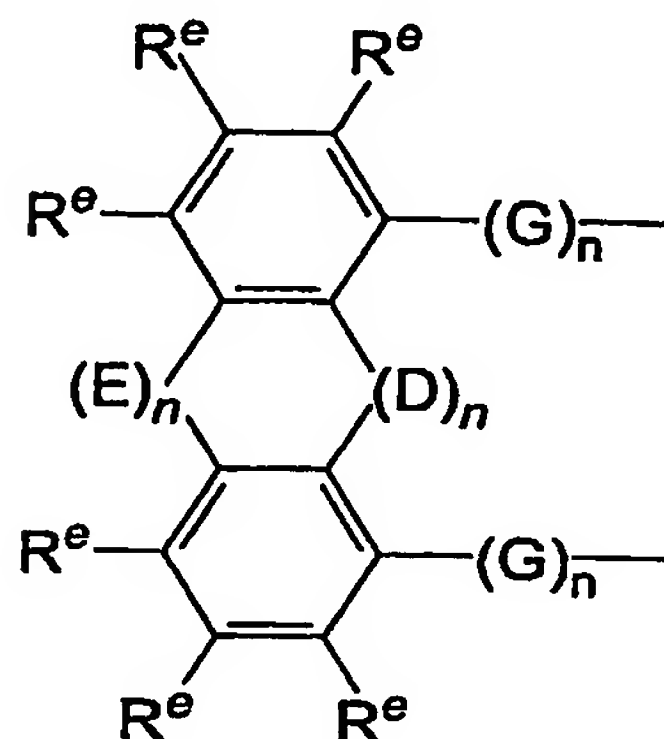
15 15. A process according to any one of Claims 12 to 14 inclusive wherein, in the ligand (L2a), (L2b) or (L2c), M^+ is an ion of an alkali or alkali earth metal, or is ammonium or a quaternary ammonium ion.

20 16. A process according to any one of Claims 12 to 15 inclusive, wherein, in the ligand (L2a), (L2b) or (L2c), X^- is an organic acid, phosphate or sulphate group.

25 17. A process according to any one of Claims 12 to 16 inclusive wherein, in the ligand (L2a), (L2b) or (L2c), W^1 , W^2 , W^3 and W^4 are each an alkyl, aryl or aryloxy radical.

30 18. A process according to Claim 17 wherein, in the ligand (L2a), (L2b) or (L2c), W^1 , W^2 , W^3 and W^4 are each an aryl or aryloxy radical in accordance with formula (1), with the proviso that the structure of formula (1) does not represent a bridging unit connecting P^a to P^b – for P^a , W^1 and W^2 represent

radicals connected through their respective G linkers, and for P^b , W^3 and W^4 represent radicals connected through their respective G linkers



(1)

wherein

- (i) all R^e are the same or are different, and are each H, alkyl, alkoxy, cycloalkyl, cycloalkoxy, heterocycloalkyl, aryl, heteroaryl, aryloxy, polyether, cyano, nitro, halogen, trifluoromethyl, $-C(O)R^c$, $-(R^d)C(O)R^c$, $-CHO$, $(R^d)CHO$, $-COOR^c$, $-(R^d)COOR^c$, $-COO^-M^+$, $-(R^d)COO^-M^+$, $-SO_3R^c$, $-(R^d)SO_3R^c$, $-SO_3^-M^+$, $-(R^d)SO_3^-M^+$, $-SR^c$, $-(R^d)SR^c$, $-SOR^c$, $-R^d(SOR^c)$, $-NR^c$, $-(R^d)NR^c$, $-N^+(R^c)(R^c)(X^-)$ or $-(R^d)N^+(R^c)(R^c)(X^-)$, wherein
- (a) R^c and R^d are the same or different, and are each H, or a branched or straight chain alkyl, alkoxy, cycloalkyl, polyether, cycloalkoxy, heterocycloalkyl, aryl, heteroaryl or aryloxy radical;
- (b) M^+ is a cation; and
- (c) X^- is an anion;
- (ii) each G is an independent linker radical, are the same or different, and is selected from $-O-$, $-N(R^f)-$, $-N^+(R^f)(R^f)(X^-)-$, $-C(R^f)(R^f)-$, $-S-$, $-Si(R^f)(R^f)-$, $-C(F_2)-$ or $-C(R^f)(F)-$, wherein
- (d) R^f is H, or a branched or straight chain alkyl, alkoxy, cycloalkyl, polyether, cycloalkoxy, heterocycloalkyl, aryl, heteroaryl or aryloxy radical,

and with the proviso that when the radical contains more than one R^f , all R^f are the same or different;

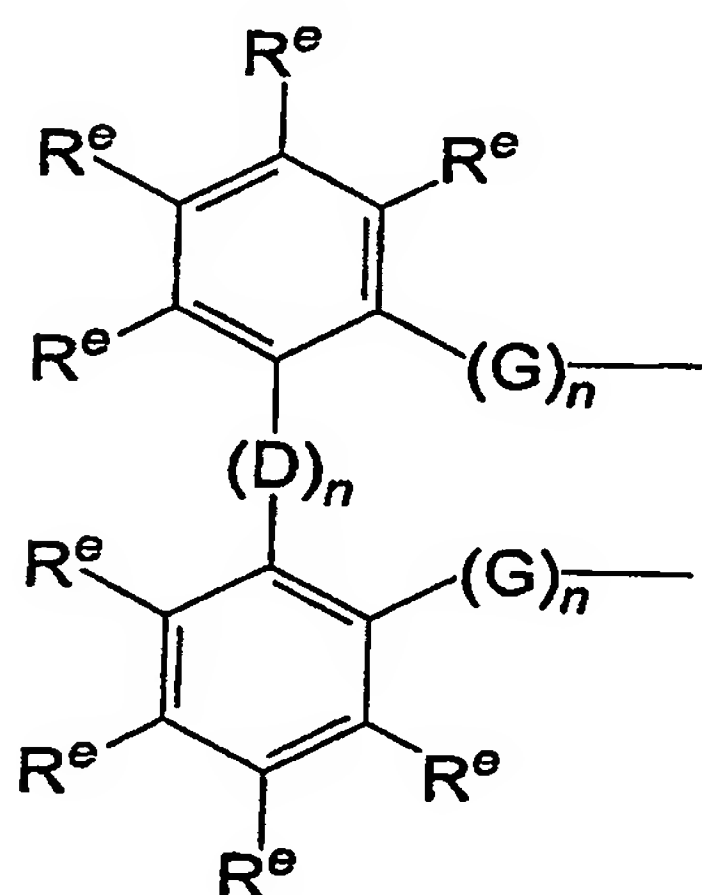
(e) X^- is as defined above; and

(iii) n (in each $(G)_n$) is 0 or 1;

5 (iv) D and E are each an independent bridge, are the same or different, and are each selected from the radical, $-O-$, $-N(R^c)-$, $-N^+(R^c)(R^c)(X^-)$, $-N(C(O)R^c)-$, $-N(SiR_2^c)-$, $-C(R^c)(R^c)-$, $-C(C(R^c)(R^c))-$; $-C(O)-$, $-S-$, $-Si(R^c)(R^c)-$, $-Si(OR^c)(OR^c)-$, $-P(R^c)-$ or $-P(OR^c)-$, wherein R^c is H, or a branched or straight chain alkyl, alkoxy, cycloalkyl, polyether, cycloalkoxy, heterocycloalkyl, aryl, heteroaryl or aryloxy radical, and X^- is as defined above;

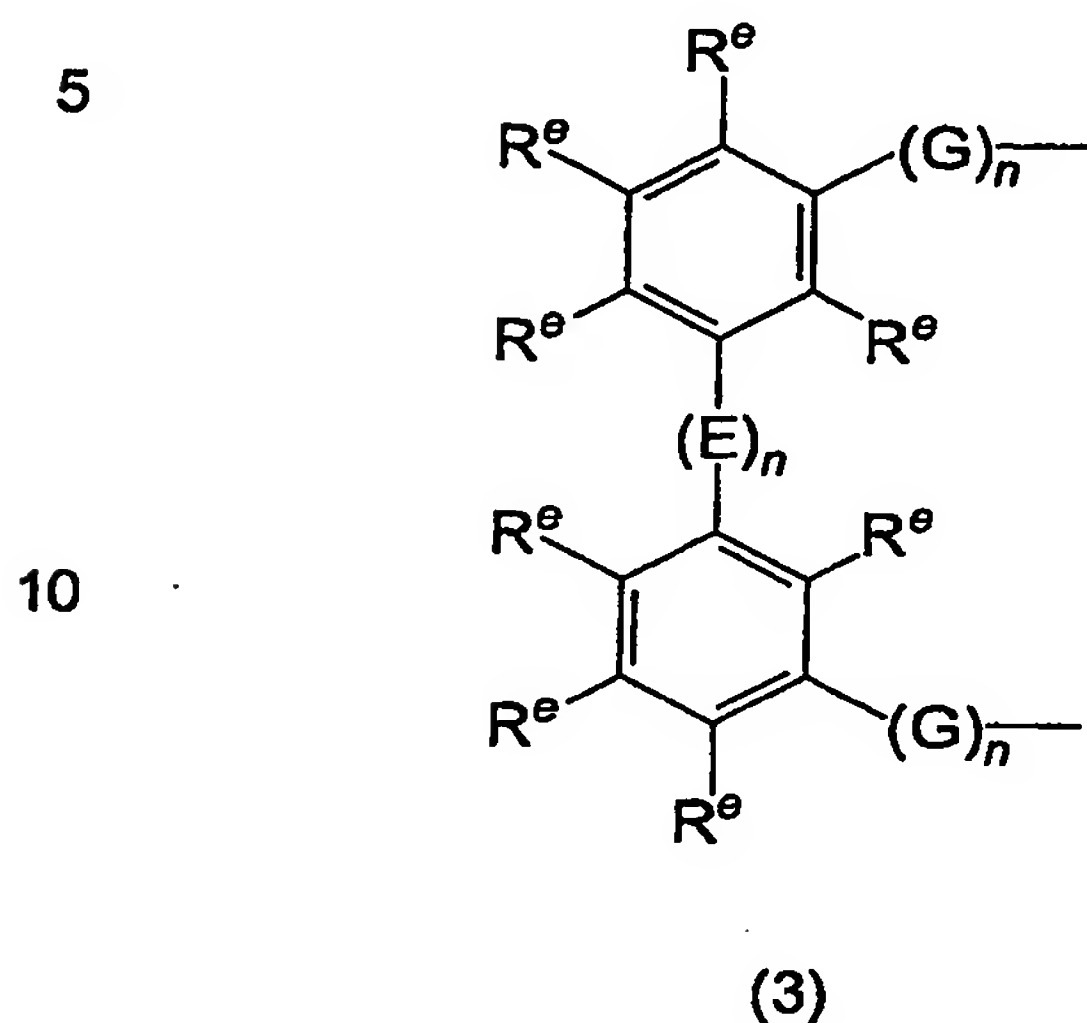
10 (v) n (in each of $(D)_n$ and $(E)_n$) is 0 or 1.

19. A process according to Claim 18 wherein, in formula (1), $n=0$, in
15 $(E)_n$, so that the independent E bridge is absent; formula (1) will then have the structure of formula (2)

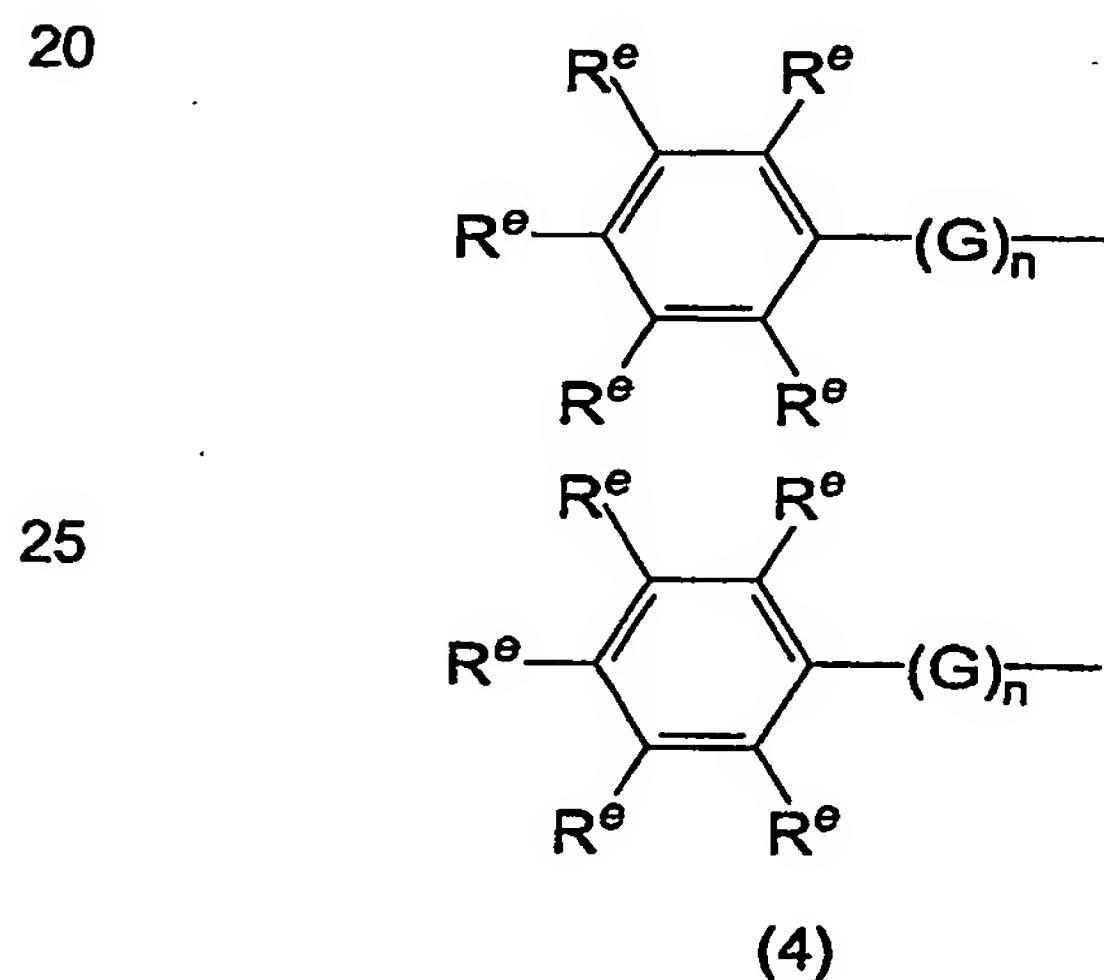


25 (2)

20. A process according to Claim 18 wherein, in formula (1), $n=0$, in $(D)_n$, so that the independent D bridging is absent; formula (1) will then have the structure of formula (3)



21. A process according to Claim 18 wherein, in formula (1), $n=0$, in both $(D)_n$ and $(E)_n$, so that both the independent bridges D and E are absent; formula (1) will then have the structure of formula (4)



22. A process according to any one of Claims 1 to 11 inclusive, wherein the bidentate phosphorus ligand is



5

(L2d)

wherein

- (i) each G is an independent linker radical, are the same or different, and is
 10 selected from $-O-$, $-N(R^f)-$, $-N^+(R^f)(R^f)(X^-)-$, $-C(R^f)(R^f)-$, $-S-$, $-Si(R^f)(R^f)-$, $-C(F_2)-$ or $-C(R^f)(F)-$, wherein
 (a) R^f is H, or a branched or straight chain alkyl, alkoxy, cycloalkyl, polyether, cycloalkoxy, heterocycloalkyl, aryl, heteroaryl or aryloxy radical, and with the proviso that when the radical contains more than one R^f , all
 15 R^f are the same or different;
 (b) X^- is an anion; and
 (ii) n (in each $(G)_n$) is 0 or 1;
 (iii) a, b, in P^a and P^b , are used merely to identify the P atoms;
 (iv) W^1 , W^2 , W^3 and W^4 are the same or different, and are each an alkyl
 20 (branched or straight chain), alkoxy, cycloalkyl, cycloalkoxy, heterocycloalkyl, aryl, heteroaryl, aryloxy or trifluoromethyl radical; and
 (v) A is a bridging unit and is selected from one of the following diradicals: $-(CR^b_2)_n-$, $-(CR^b)_n-$, $-(CR^bCR^b)_n-$, $-[C(O)]_n-$, $-[C(O)C(R^b)_2]_n-$, $-(NR^b)_n-$, $-S-$, $-(SiR^b_2)_n-$, $-(SiOR^b_2)_n-$, with
 25 (c) any alkyl radical having $n = 1$ to 5 and being cyclic, straight or branched or straight;
 (d) R^b being H, alkyl, alkoxy, cycloalkyl, cycloalkoxy, heterocycloalkyl, aryl, heteroaryl, aryloxy, polyether, cyano, nitro, halogen, trifluoromethyl, $-C(O)R^c$, $-(R^d)C(O)R^c$, $-CHO$, $(R^d)CHO$, $-COOR^c$, $-(R^d)COOR^c$, $-COO^-M^+$,
 30 $-(R^d)COO^-M^+$, $-SO_3R^c$, $-(R^d)SO_3R^c$, $-SO_3^-M^+$, $-(R^d)SO_3^-M^+$, $-SR^c$, $-$

$(R^d)SR^c$, $-SOR^c$, $-R^d(SOR^c)$, $-NR^c$, $-(R^d)NR^c$, $-N^+(R^c)(R^c)(X^-)$ or $-(R^d)N^+(R^c)(R^c)(X^-)$, wherein

5 (e) R^c and R^d are the same or different, and are each H, or a branched or straight chain alkyl, alkoxy, cycloalkyl, polyether, cycloalkoxy, heterocycloalkyl, aryl, heteroaryl or aryloxy radical;

(f) M^+ is a cation; or

(vi) A is a bridging unit and is '-Ar-', which is an aryl or heteroaryl group of between 4 and 18 carbon atoms.

10 23. A process according to any one of Claims 1 to 22 inclusive, wherein the reaction temperature is from 50°C to 150°C; the synthesis gas pressure under which the hydroformylation reaction is performed is from 1 to 100 bar; and the $H_2:CO$ ratio is from 1:10 to 100:1.

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